The authors are to be congratulated on showing the thin ice cloud radiative effects over the polar region using two profiles obtained from aircraft measurements during the Polar Stratosphere in a Changing Climate (POLSTRACC) campaign. I enjoyed reading this manuscript, particularly the instrumentation and data processing section which I am unfamiliar with. Obviously, only two ice water content (IWC) profiles cannot fully describe the cloud variability over the Arctic. However, by making use of the two profiles, the authors study the sensitivities of cloud radiative effects to solar zenith angle and surface albedo variations. The authors also study the difference in computed cloud radiative effects between using IWC aircraft measurement and optically equivalent constant IWC. How the aircraft measurement data are used to prepare the ice cloud description for the radiation computations is nicely presented in detail. All the assumptions made in the radiation computations are clearly stated. The only problem I have is that the computed longwave irradiance variation within the cloud layer looks strange to me and appears to contrast with the results in numerous previous studies. Hence, I would like to suggest the authors double check the longwave radiation computations in this study. Beyond this problem, this manuscript is clear, organized, and well-written and I would suggest it be accepted for publication after some revisions if needed. My specific comments are as follows:

Major comments:

Lines 171-173. Is the air in the (polar) stratosphere generally descending? What is the situation in the troposphere, particularly the upper troposphere that is of interest in this study? Is the air in the troposphere also generally descending? If the upper tropospheric air was also descending during the two months of interest, why do you think the mass accumulation near the tropopause during the two months was a result of the descending motion in the stratosphere? If the steady descending motion in the stratosphere exists and persists, will the static stability of the tropopause become increasingly higher as time goes by?

Figure 12. Numerous studies have shown that cloud longwave radiative heating/cooling rate have a vertical gradient from cloud base to cloud top, i.e., heating at the cloud base and cooling at the cloud top (e.g., Fu et al., 1997; Ren et al., 2020, 2021; Wall et al., 2020). However, the red curves in Fig. 12(a) and 12(d) show the opposite, i.e., longwave radiative cooling at the cloud base and heating at the cloud top. I used the longwave version of the rapid radiative transfer model (RRTM; Iacono et al., 2000) with scattering included (Tang et al., 2018) to do a quick check. The resultant longwave irradiance (I_{LW}) and radiative heating/cooling rate (H_{LW}) profiles are shown in the figure below:

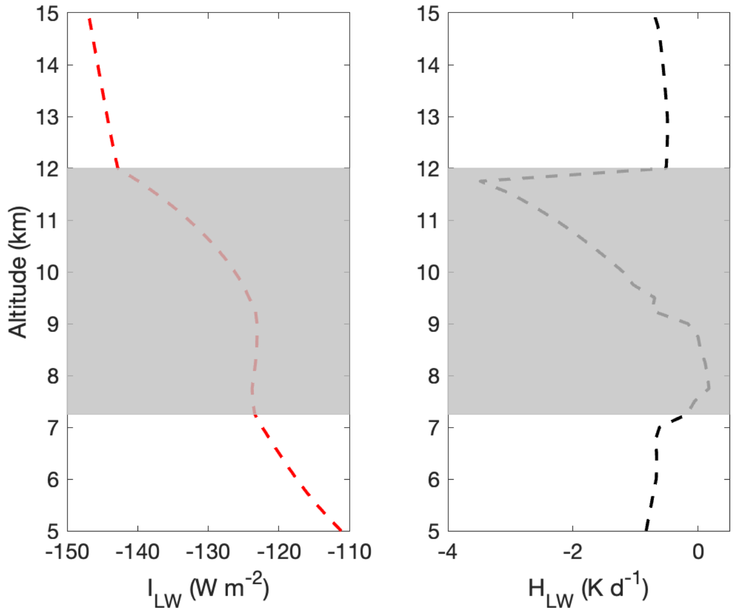

Figure C1. Longwave irradiance (I_{LW}) and radiative heating/cooling rate (H_{LW}) profiles in an RRTM experiment.

In this RRTM experiment, a homogeneous ice cloud layer with constant IWC of 0.0032 g m^{-3} is placed between 7.25 and 12 km; a constant effective radius of 23 μm is assumed; a subarctic winter atmospheric profile is adopted with surface temperature set to 280 K and surface emissivity set to 1. Such settings in the RRTM experiment resemble the case of January 25, 2016 in this study. As shown in the above figure, the decrease of I_{LW} with height is slower in the lower portion of the cloud layer, whereas in Fig. 12(a) and 12(d) the decrease of I_{LW} with height is slower in the upper portion of the cloud layer. Would it be helpful to double check your longwave radiation computations? What radiative transfer solver in libRadtran did you use for the longwave radiation computations? Will the I_{LW} result change if you switch to using another solver, such as DISORT?

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Minor comments:

Line 29. "trough" or "through"?

Line 80. It looks "CIRRUS-HL" is a contraction, but it is not spelled out when it first appears in this article here.

Lines 102-104. Is water vapor mixing ratio much higher than the saturation mixing ratio in a homogenous ice nucleation environment? I notice that as shown in Fig. 3 the POLSTRACC cirrus measurements were taken at temperatures between 195 and 250 K. Do you know if there are previous studies of the importance of homogenous vs. heterogenous ice nucleation in the polar atmosphere with this temperature range?

Line 118. It looks "FISH" is a contraction, but it is not spelled out when it first appears in this article here.

Line 174. Does the "latter" refer to "dynamical tropopause"? Why is the dynamical tropopause a transport barrier of air masses?

Lines 175-176. You mean the observed cirrus clouds above the dynamical tropopause will eventually become polar stratospheric clouds (PSCs)? How are PSCs defined? What are the criteria used to judge whether a cloud is a PSC?

Lines 180-182. Is the thermal tropopause the local temperature minimum? However, as shown in Fig. 4, what the authors refer to as "stratospheric cirrus" show the lowest temperatures, making me wonder if these "stratospheric cirrus" clouds are also below the thermal tropopause?

Lines 298-299. The agreement between aircraft and reanalysis water vapor data surprises me. This result suggests that the quality of ECMWF IFS analysis water vapor data is very good, at least over Northern Europe.

Lines 355-357. These two sentences read awkward to me. Correct me if I am wrong, basically you wanted to say increased optical thicknesses of ice clouds increase the cloud LW effect (forcing), i.e., making more surface emitted LW radiation absorbed by ice clouds and hence $F_{\mathrm{net,TOA,LW}}$ less negative?

Lines 362-363. I cannot understand this sentence “a transition that is shifted towards larger sza when compared to the curves in Figs. 8a, b”.

Line 419. “shadowing effects”? What do you mean by “shadowing effects”? Didn’t you set the cloud fraction to 1 in each cloud layer in your radiation computations? In other words, every cloud layer is overcast in your computations, isn’t it? If so, cloud overlapping does not matter in your computations.

Lines 421-422. Does this sentence talk about the case on March 9, 2016?